

6.3.3 MEASUREMENT

In situ measurement generally is preferred for determining the conductivity of surface water; downhole or flowthrough-chamber measurements are preferred for ground water. Be alert to the following problems if conductivity is measured in an isolated (discrete) sample or subsample:

- ▶ The conductivity of water can change over time as a result of chemical and physical processes such as precipitation, adsorption, ion exchange, oxidation, and reduction—Do not delay making conductivity measurements.
- ▶ Field conditions (rain, wind, cold, dust, direct sunlight) can cause measurement problems—Shield the instrument to the extent possible and perform measurements in a collection chamber in an enclosed vehicle or an on-site laboratory.
- ▶ For waters susceptible to significant gain and loss of dissolved gases, make the measurement within a gas-impermeable container (Berzelius flask) fitted with a stopper—Place the sensor through the stopper and work quickly to maintain the sample at ambient surface-water or ground-water temperature.
- ▶ Avoid contamination from the pH electrode filling solution—Measure conductivity on a separate discrete sample from the one used for measuring pH; in a flowthrough chamber, position conductivity sensor upstream of the pH electrode.

Conductivity must be measured in the field.

Document the precision of your measurements. Precision should be determined about every tenth sample or more frequently, depending on study objectives. Successive measurements should be repeated until they agree within 5 percent at conductivity $\leq 100 \mu\text{S}/\text{cm}$ or within 3 percent at conductivity $> 100 \mu\text{S}/\text{cm}$.

The conductivity measurement reported must account for sample temperature. If using an instrument that does not automatically temperature compensate to 25°C , record the uncompensated measurement in your field notes, along with the corrected conductivity value. Use correction factors supplied by the instrument manufacturer if available; otherwise, refer to table 6.3–3.

SURFACE WATER 6.3.3.A

Surface-water conductivity should be measured in situ, if possible; otherwise, determine conductivity in discrete samples collected from a sample splitter or compositing device. Filtered samples may be needed if the concentrations of suspended material interfere with obtaining a stable measurement.

In situ measurement

Conductivity measurements in flowing surface water should represent the cross-sectional mean or median conductivity at the time of observation (see step 7, below). Any deviation from this convention must be documented in the data base and with the published data.

First:

- ▶ Take a cross-sectional conductivity profile to determine the degree of system variability. A submersible sensor works best for this purpose.
- ▶ Refer to NFM 6.0 for criteria to help decide which sampling method to use.

Next, follow the 7 steps listed below:

1. Calibrate the conductivity instrument system at the field site after equilibrating the buffers with stream temperature.
2. Record the conductivity variation from a cross-sectional profile on a field form and select the sampling method.
 - **Flowing, shallow stream**—wade to the location(s) where conductivity is to be measured.
 - **Stream too deep or swift to wade**—lower a weighted conductivity sensor from a bridge, cableway, or boat. Do not attach weight to the sensor or the sensor cable.
 - **Still-water conditions**—measure conductivity at multiple depths at several points in the cross section.

3. Immerse the conductivity and temperature sensors in the water to the correct depth and hold there (no less than 60 seconds) until the sensors equilibrate to water conditions.
4. Record the conductivity and corresponding temperature readings without removing the sensors from water.
 - Values should stabilize quickly to within 5 percent at conductivity ≤ 100 $\mu\text{S}/\text{cm}$ and within 3 percent at conductivity > 100 $\mu\text{S}/\text{cm}$.
 - Record the median of the stabilized values on field forms.
 - If the readings do not meet the stability criterion after extending the measurement period, record this difficulty in the field notes along with the fluctuation range and the median value of the last five or more readings.
5. For EWI or EDI measurements, proceed to the next station in the cross section and repeat steps 3 and 4. Record on field forms the mean (or median, if appropriate) value for each subsection measured.
6. When the measurement is complete, remove the sensor from the water, rinse it with deionized water, and store it.
7. Record the stream conductivity on the field forms:
 - **In still water—median** of three or more sequential values.
 - **EDI—mean** value of all subsections measured (use the median if measuring one vertical at the centroid of flow).
 - **EWI—mean or median** of all subsections measured (see NFM 6.0).

Subsample measurement

Representative samples are to be collected and split or composited according to approved USGS methods (Wells and others, 1990). Measure the conductivity of samples as soon as possible after collection. If the sample cannot be analyzed immediately, fill a bottle to the top, close it tightly, and maintain the sample at stream temperature until measurement.

Reported conductivity values normally are determined on an unfiltered sample. Large concentrations of suspended sediment can be a source of measurement error—record such conditions in the field notes.

- ▶ If sediment concentrations are heavy, measure conductivity on both unfiltered and filtered subsamples and record both values on the field form.
 - ▶ If the conductivity value differs significantly between the filtered and unfiltered samples, report the filtered value as sample conductivity and identify it as a “filtered sample.”
1. Calibrate the conductivity instrument system at the field site.
 2. Select the sampling method (see NFM 6.0) and collect a representative sample.
 3. Withdraw a homogenized subsample from a sample splitter or compositing device. Rinse the sample bottles three times with the sample—rinse them with sample filtrate, for filtered samples.
 4. Rinse the conductivity sensor, the thermometer (liquid-in-glass or thermistor), and a container large enough to hold the dip-type sensor and the thermometer.
 - a. First, rinse the sensor, the thermometer, and the container three times with deionized water.
 - b. Next, rinse the sensor, the thermometer, and the container using sample water.
 5. Allow the sensors to equilibrate to sample temperature, then discard the used sample water. Pour fresh sample water into a container holding the sensor and the thermometer. **When using a dip-type sensor, do not let the sensor touch the bottom or sides of the measuring container.**
 6. Measure water temperature.
 - If the conductivity sensor contains a calibrated thermistor, use this thermistor to measure water temperature.
 - If the instrument is not temperature compensating, use a calibrated thermistor or a liquid-in-glass thermometer.
 - Adjust the instrument to the sample temperature (if necessary) and remove the thermometer.
 7. Measure conductivity.
 - a. Remove any air trapped in the sensor by agitating the sensor up and down under the water surface.
 - b. Read the instrument display.
 - c. Agitate the sensor up and down under the water surface, and read the display again.
 - d. Repeat the procedure until consecutive readings are the same.

8. Record the conductivity and the sample temperature on field forms.
 - If the instrument is not temperature compensating, record the raw data and convert the values to conductivity at 25°C using temperature-correction factors provided by the manufacturer.
 - Report the median of the readings to three significant figures on the field forms.
 - Discard the sample into a waste container and dispose according to regulations.
9. **Quality control—**
 - Repeat steps 3 through 8 with at least two fresh subsamples, rinsing the instruments once only with sample water.
 - Subsample values should be within ± 5 percent for conductivity $\leq 100 \mu\text{S/cm}$, or ± 3 percent for conductivity $> 100 \mu\text{S/cm}$.
 - If criteria cannot be met: filter the samples, report the median of 3 or more samples, and record this difficulty in field notes.
10. Rinse the sensor, the thermometer, and the container with deionized water. If another measurement is to be made within the next day or two, store the sensor in deionized water. Otherwise, store the sensor dry.

GROUND WATER 6.3.3.B

Measurements of ground-water conductivity must represent aquifer conditions. Temperature changes resulting from transporting a well sample to land surface can affect conductivity.

- ▶ To minimize the effect from temperature changes, measure conductivity as close to the source as possible, using either a downhole or flowthrough-chamber sampling system (refer to NFM 6.0 for details).
- ▶ Bailed or other methods for collecting discrete samples isolated from the source are not recommended as standard practice, although such methods are sometimes called for owing to site characteristics or other study requirements.

Downhole and flowthrough-chamber measurement

1. Calibrate the conductivity instrument system on site.
 - Bring standard solutions to the temperature of the water to be sampled by suspending the standards in a bucket into which well water is flowing. Allow at least 15 minutes for temperature equilibration. Do not contaminate standards with sample water.
 - a. Check the temperature of the water flowing into the bucket against that of standards.
 - b. Check that the thermometer (usually a thermistor function in the conductivity meter) has been certified within the past 4 months for the temperature range to be measured.
 - After calibration, rinse the conductivity and temperature sensors thoroughly with deionized water.
2. Install the conductivity and temperature sensors.
 - **Downhole system**—Lower the conductivity and temperature sensors to sampling point, followed by pump.
 - a. Remove any air from the system by agitating the conductivity sensor up and down under the water; read the instrument display.
 - b. Repeat this procedure until rapid consecutive readings are approximately the same.

- **Flowthrough-chamber system**—Install the chamber system as close to the well as possible and shield the system from direct sunlight.
 - a. Position the conductivity sensor upstream from the pH electrode.
 - b. Direct flow to the chamber after an initial discharge to waste to clear sediment from sample line.
 - c. Release any air trapped in the chamber.
 - d. Agitate the conductivity sensor up and down under the water to remove air from system. Rapid consecutive readings should be about the same.
- 3. During purging (table 6.0–1 in NFM 6.0):
 - Keep flow constant and laminar.
 - Allow the sensors to equilibrate with ground-water temperature for 5 minutes or more at the flow rate to be used for collecting all other samples.
- 4. Measure conductivity and associated temperature at regular intervals throughout purging; record the conductivity values and the associated temperature in the field notes.
 - If the conductivity sensor contains a calibrated thermistor, use this thermistor to measure water temperature.
 - If the instrument is not temperature compensating, install a calibrated thermometer in the flowthrough chamber, record raw data, and apply correction factors.
- 5. Check the variability of the conductivity values toward the end of purging.
 - The stability criterion is met when five readings taken at regularly spaced intervals of 3 to 5 minutes or more are within
 - ± 5 percent for conductivity $\leq 100 \mu\text{S/cm}$
 - ± 3 percent for conductivity $> 100 \mu\text{S/cm}$
 - When readings fluctuate rapidly, record the median of three or more readings within about 60 seconds as the value for a specific time interval.
 - If the criterion is not met, extend the purge period in accordance with study objectives and continue to record measurements at regularly spaced time intervals. Record this difficulty on the field forms.

6. Report conductivity.
 - Record the final five values on field forms.
 - Report the median value of the final five measurements as the sample conductivity.
 - If values exceed the stability criterion, report the range of values observed for the time interval, along with the median of the final five or more values.

Subsample measurement

Conductivity measurements reported from bailed or other discrete samples need to be identified in the data base, indicating the sampling method used. Refer to 6.0.3.B in NFM 6.0 for use of bailers and the subsample method.

1. Calibrate the conductivity instrument system onsite.
 - Bring standard solutions to the temperature of the water to be sampled by suspending the standards in a bucket into which well water is flowing. Allow at least 15 minutes for temperature equilibration. Do not contaminate standards with sample water.
 - a. Check the temperature of the water flowing into the bucket against that of standards.
 - b. Check that the thermometer (usually a thermistor function in the conductivity meter) has been certified within the past 4 months for the temperature range to be measured.
 - After calibration, rinse the conductivity and temperature sensors thoroughly with deionized water.
2. Draw off subsamples for measurement.
 - **Quality control—Collect three subsamples to check precision.**
 - If samples need to be stored for a short time, or if several subsamples will be measured, collect sample aliquots in separate field-rinsed bottles—fill to the brim, cap tightly, and maintain at ambient ground-water temperature. Measure conductivity as soon as possible.

3. Follow procedures described in steps 4 through 10 for “Subsample measurement” of surface water (6.3.3.A).

TECHNICAL NOTE: If the sample is measured in an open container and readings do not stabilize within several minutes, the cause may be CO₂ degassing—use a closed system to measure the sample. Filter the conductivity sample if the settling of clay particles appears to interfere with the stability of the readings.